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1235926

DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO METHODS AND APPARATUS SUITABLE FOR USE IN FORMING PELLETS

(71) We, USM CORPORATION (formerly United Shoe Machinery Corporation), of Flemington, New Jersey, United States of America, a Corporation duly organised under the laws of said State of New Jersey, having a place of business at 140 Federal Street, Boston, Commonwealth of Massachusetts, United States of America; do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with improvements in or relating to methods and apparatus suitable for use in forming pellets and especially forming pellets from a slurry including nitrocellulose.

There are described in the complete specification of our co-pending patent application No. 4555/67 Serial No. 1171338 explosive charges in pellet form adapted for use in a combustion chamber of an explosively actuated tool in which chamber the charge may explosively deflagrate when percussed, the charge being homogeneous, primerless and comprising compacted nitrocellulose.

There is hereinafter described to illustrate the invention by way of example a machine suitable for use in forming pellets from an aqueous slurry of particulate, fibrous nitrocellulose comprising a plurality of tubular dies carried by a head, each die having an associated pair of formers arranged to enter the die one from each end, feed means for supplying a slurry to dies disposed at a loading station comprising fibrous nitrocellulose, water and a stabilizer e.g. diphenyl amine, is circulated in the operation of the illustrative machine, exhaust means arranged to apply suction in the operation of the illustrative machine to dies at the loading station and control means comprising cam means for controlling relative movement of the formers of each pair in the operation of the illustrative machine whereby to subject to pressure there between slurry fed to the dies by said feed means. The illustrative machine further comprises drive means including a motor arranged to continuously rotate the head in the operation of the illustrative machine whereby to carry the dies in succession past the feed means where each die is filled with slurry which as the die is carried round by the head is thereafter dried, trimmed to preselected size and subjected to pressure by the formers to form a pellet which is ejected from the die just prior to the die again reaching the feed means.

The invention provides a machine suitable for use in forming pellets by compression of slugs of matted fibrous material obtained from a slurry, comprising a plurality of tubular dies having passages through their walls through which suction can be applied to the interior of the dies, a pair of formers associated with each die in such a manner that one former enters the die from one end and the other from the other, control means for controlling relative movement between the formers of each pair and between the formers and their associated die, means for trimming the slugs by removing slug material projecting from the dies, exhaust means arranged to apply suction through the passages in the walls of the dies, and feed means operative at a loading station for supplying slurry to the dies, the construction and arrangement of the machine being such that at the loading station each die, with one of the formers obstructing one end, is subject to suction applied through the passages in its wall to rapidly cause a slug of matted fibrous material to be formed in the die from the slurry and thereafter in the operation of the machine, the former obstructing the die at one end is advanced to cause a portion of the slug to project beyond the die, the slug is trimmed by removal of the projecting portion, and the slug is subjected in the die to compression between the formers to provide a pellet.

There now follows a detailed description, to be read with reference to the accompanying

drawings, of the illustrative machine aforementioned. It is to be understood that this illustrative machine has been selected for description to illustrate the invention by way of example and not of limitation thereof.

In the accompanying drawings:—

Figure 1 is a view in front elevation of the illustrative machine;

Figure 2 is a view largely in section on the line II—II of Figure 1;

Figure 3 is a perspective view showing an upper portion of a forming head of the illustrative machine with covers and guards removed;

Figure 4 is a schematic view in section, showing a die cavity of the illustrative machine being loaded;

Figure 5 is a schematic view in section showing a cut-off station of the illustrative machine;

Figure 6 is a view in section showing a pair of formers at one stage of compacting a slug;

Figure 7 is a perspective view of a pellet formed by the illustrative machine;

Figure 8 is a diagrammatic view showing relative heightwise positions of the upper and lower formers throughout a cycle of operation of the illustrative machine.

Figure 9 is a schematic view similar to Figure 8 indicating the sequence of functions in each cycle;

Figure 10 is a plan view of cams controlling the lower formers of the illustrative machine; and

Figure 11 is a view in section, with parts broken away, showing some of the dies in relation to loading, trimming, and pellet ejecting means.

Referring to Figures 1 and 2, the illustrative machine comprises a fixed cast frame having a lower base portion 10 and an integral upper bearing column 12. This column carries a rotary forming head 14 supported on a thrust bearing 16 (Figure 2). For receiving and segregating particulate material in the form of fibres, in this instance nitrocellulose circulated in a slurry consisting only of water and a diphenylamine stabilizer the ratio of water to nitrocellulose being in the range of from 5:1 to 12:1, the head is formed with cylindrical bores 17 (Figures 4 to 6) disposed to receive a plurality of circularly arranged, equi-spaced tubular dies 18, a total of 24 dies being used in the illustrative machine. The dies 18 in the course of their revolution receive in cylindrical cavities 19 (Figures 3 to 6) thereof cooperating, vertically aligned, upper and lower formers 20, 22 respectively.

For driving the head 14, a variable speed motor-reducer 24 (Figure 1) is connected by an endless belt 26 to a pulley 28 (Figure 2) on one end of a cross shaft 30 the other end of which drives meshing bevel gears 31, 32 (Figure 1). The gear 32 is rotatably connected to the head 14 by means including a stub shaft 34, and a pinion 36 thereon meshing with a ring gear 38 affixed to the head.

Vertical positioning of the upper formers 20 of the illustrative machine is controlled by control means shown in Figures 2 and 3 and comprising an upper pressure roll 40 and an upper cam 42 having a circular cam track formed to receive followers 44 on the upper ends of the formers 20. Similarly, the lower formers 22 are respectively provided at their lower ends with followers 46 (Figure 2) arranged to cooperate in succession with a circular series of lower cams of the control means and a lower pressure roll 48 (Figures 1 and 2) cooperative with the roll 40 for effecting maximum compression of the pellets P. The lower cams comprise a pellet eject cam 50 (Figure 10), a former retract cam 52, a holddown cam 53, a cut-off adjust cam 54, and a precompression cam 56 fixedly secured to the frame 10. The upper cam 42 is secured to a bracket 58 bolted onto the column 12, the bracket serving with an upstanding rear portion 60 (Figure 2) of the frame 10 rotatably to support a bearing shaft 62 for the upper pressure roll 40.

For adjusting and precisely determining final forming compression effected by the rolls 40, 48 and hence creating the desired porosity of pellets P made by the illustrative machine, the lower roll 48 is floatingly carried by linkage including a lever 64 (Figures 1 and 2) one end of which is pivoted to the frame 10 and the other end of which is pivotally connected to a link 66 (Figure 1). The latter is itself carried by a lever 68 one end of which is pivoted to the frame 10 at 70, and the other end of which is yieldingly supported on a plunger 72 urged upwardly by a compression spring 74 (or other resilient means e.g. an air actuated diaphragm) carried in a cylindrical housing 76 mounted at its lower end on the frame 10. The plunger 72 threadedly carries a hand wheel 78 by means of which the plunger can be moved accurately heightwise, and hence the degree of resistance to final compression of a pellet by the roll 48 selectively adjusted to determine pellet density.

Description of additional structure of the illustrative machine will now continue in the order of its function in a cycle of operation of the illustrative machine, considering this cycle to commence at a loading station generally designated 80 (Figures 2, 3, 9, 11) wherein the dies 18 are to be loaded.

The slurry is preferably constantly stirred in a storage vat and continuously recirculated in a supply and return system including a delivery pipe 82 (Figures 1 to 3) connected to a feed head 84 over-lying the loading portion of a flat table 86 (Figures 2, 3, 9) constituting an annular portion of the head 14. The tops of the dies 18 preferably are secured even with the surface of the table 86 as by means of die locks 88 (Figures 3 and 11) inserted radially in the table 86. Preferably pumping means,

not shown, is provided for maintaining the circulation of slurry under an adjustable, selected pressure. The feed head 84 is formed with a cavity 90 (Figures 2, 4, 9, 11) of a configuration to overlie more than one of the die cavities 19, in this case three cavities 19, as shown in Figure 11. The feed head also has communicating with it an outlet pipe 92 for returning unused slurry to be recirculated. At the loading station 80 the upper formers 20 are retracted out of the dies to positions above the feed head 84, and the lower formers 22 are caused to descend in the loading cavities to a level determined by the retract cam 52.

An important feature of the loading station 80, and in subsequent operating stations as will be noted, is the provision of a multi-purpose exhaust means communicating with the cavities 19. Before describing this exhaust means, it should be noted that the formers 20, 22 preferably have a stem diameter, adjacent to their respective forming ends, which is just enough smaller than that of the cavities 19 to afford a radial clearance allowing the passage of excess water exuded from the slurry yet tending to obstruct the passage of solid materials such as nitrocellulose fibres. In order ultimately to produce finished pellets P of uniform density and size, it is desirable to retain for processing in the cavities 19 an adjustable, precisely selected volume of the particulate material. To this end, the material is accumulated in the form of a wet slug S (Figure 5) on the lower former 22 as exactly positioned in the die cavity 19 by the cam 53, their matting and the initial cavity purging to insure rapid, complete charging being assisted by the exhaust means comprising an evacuable chamber 94 (Figures 1, 2, 3 and 11) communicating with the cavities 19 being loaded. By placing more than one die cavity under the feed head 84 and subjecting these to vacuum exhaust simultaneously, more uniform loading is believed to be attained since surging peak demands on the vacuum system are lessened. Preferably, for drying purposes, a right-hand section of the chamber 94 as shown in Figures 3 and 11 also communicates with at least one previously fully loaded cavity 19. It has been found that without the aid of the exhaust means the cavities 19 are not reliably loaded to the density required. The cavities 19 of the illustrative machine communicate with the chamber 94 through passages comprising radial table vents 96 and a plurality of radial die bores 98 (Figures 4 and 5) of a reduced diameter of the order of 0.040 inch for passing water and obstructing the fibres to facilitate their matting and slug build-up.

In Figures 4 and 5 the die bores 98 are inclined downward toward the die cavity 19 thus affording a longer slug S than when, alternatively, horizontal or upwardly inclined die bores 98 are employed as shown in Figure 6. As best seen in Figures 4, 5 and 11, outer end portions of the vents 96 open into a circular groove 100 in the table 86, the chamber 94 having spaced sealing means engaging the groove for maintaining effective exhaust condition. The chamber 94 has exhaust outlets 104, 104 which are in communication with a manifold 106 (Figure 2) secured to the frame portion 60.

On emerging from the feed head 84 the successive dies 18 will have been loaded with wet fibres matted to form the slugs S (Figures 5, 9) bottomed on the lower former 22 and having a rough irregular upper surface. It is in this condition that the exhaust chamber 94 performs its final drying treatment. The slugs next progress through a cut-off station 108 (Figures 1, 3, 5, 9, 11) where each successive lower former is caused by the cam 54 to move upwardly to block the bores 98 and then project the irregular unwanted upper portion of the slug above the table 86 and into the operating path of slug trimming means now to be described, thus leaving an exact predetermined amount of pellet material to be formed.

As shown in Figures 3 and 5, the slug trimming means comprises a block 110 having a passage 112 for supplying water under pressure in a continuous fine jet from an orifice 114 (Figure 5) arranged to emit its jet in a cutting path substantially parallel to the upper surface of the table 86. The feed head 84 and the block 110 are mounted on the chamber 94, and the latter is secured on a support plate 116 secured to the base portion 10. For recirculating the water and the removed excess slug material, an exhaust passageway 118 in the block 110 communicates with the manifold 106. All recirculated fluid may pass through a precipitating zone (not shown) wherein nitrocellulose is separated for reuse.

Referring to Figure 8, after each slugs S has been trimmed, both upper and lower formers 20, 22 descend in the die 18, but first, while the bores 98 remain blocked by the former 22, the upper die 20 alone descends so that the slug passes through a precompression zone as shown in Figures 6, 8 in which gradual compression and forming of the slug is effected. Too rapid compression of nitrocellulose, even though the fibres are still moist, as is well-known can cause an explosion when the compacted fibres are pressed against and confined within a substantially closed cavity, e.g. as defined by the circumferential wall of the cavity 19 and the adjacent ends of the formers 20, 22.

The formers of the illustrative machine are provided with web forming annular projections 120, to produce a symmetrical pellet P (Figure 7) having an internal web 122 which is thinner than other portions of the pellet. Porosity of the web 122 usually does not significantly differ from the remainder of its pellet and is usually uniform to serve ultimately as a bridge in transmitting burning from a central impact

ignition locality 124 to the thicker outer pellet walls. Final compression of the pellets is effected in the illustrative machine between the rolls 40, 48, which apply to the formers 20, 22 pressure only slightly greater than the maximum pressure of the precompression zone. If desired, such final compression can be effected in a separate press adapted for the purpose. Nitrocellulosic pellets P having a diameter in the order of .340" are subjected to a final load of about 5000 lbs.

After progressing through the rolls 40, 48 the upper formers 20 are re-elevated to out-of-the-way positions above the dies 18, and the lower formers 22 are successively raised by the eject cam 50 to thrust the formed pellets P axially from the cavities 19. As soon as the formers 22 have effected pellet ejection, they are retracted within the die cavities 19 by the cam 52 to re-open the radial bores 98 thus to enable air under pressure to be admitted thereto from a tube 126 (Figure 11) having communication with the groove 100 and the vents 96. This scavenging air blast lifts the ejected pellet, which is still slightly soft but stable enough to be handled, from the mouth of the die bore sufficiently to be carried by means for removing the pellets comprising a water jet from a supply pipe 128 directly into an exit tube 130. The latter is normally inclined downwardly and away from the machine to deliver the pellets P into a wire mesh container, for example, or onto a suitable conveyor (not shown) where the carrying water is collected and recirculated. The cycle is now completed and the dies 18 are ready to pass once again through the loading station 80.

The illustrative machine has been found effective, safe and efficient in the production of fibrous articles of selected uniform weight and size. For example, uniform propellant charges of nitrocellulose fibre have been produced in lots having, respectively, selected net weights varying from about 115 milligrams to roughly twice as much, with a tolerance range of only about plus or minus 5—10 milligrams per charge. Experience indicates that density of propellant charges may advantageously be slightly varied as desired for different production batches by pursuing one or more of the following steps: (a) changing the proportion of water to nitrocellulose in the slurry; (b) changing the pressure under which the slurry is circulated; (c) changing the duration or strength of the drying suction; (d) changing the mass of slug material retained for compression forming; and (e) changing the degree of compression applied to the moist slug.

WHAT WE CLAIM IS:—

1. A machine suitable for use in forming pellets by compression of slugs of matted fibrous material obtained from a slurry, comprising a plurality of tubular dies having passages through their walls through which suction can be applied to the interior of the dies, a pair of formers associated with each die in such a manner that one former enters the die from one end and the other from the other, control means for controlling relative movement between the formers of each pair and between the formers and their associated die, means for trimming the slugs by removing slug material projecting from the dies, exhaust means arranged to apply suction through the passages in the walls of the dies, and feed means operative at a loading station for supplying slurry to the dies, the construction and arrangement of the machine being such that at the loading station each die, with one of the formers obstructing one end, is subject to suction applied through the passages in its wall to rapidly cause a slug of matted fibrous material to be formed in the die from the slurry and thereafter in the operation of the machine, the former obstructing the die at one end is advanced to cause a portion of the slug to project beyond the die, the slug is trimmed by removal of the projecting portion, and the slug is subjected in the die to compression between the formers to provide a pellet.

2. A machine according to claim 1 wherein the dimensions of each die and its associated formers are such that a drainage clearance is provided between the outer periphery of the formers and the interior of the die, said clearance being so dimensioned as to impede the flow of solids of the slurry between the die and the formers while permitting flow of liquid.

3. A machine according to claim 2 wherein the interior of each die is cylindrical, the passages in the wall of the die radiate from a plane intermediate the ends of the die, and the control means is arranged to position an end portion of the former which is obstructing the die at one end of the loading station adjacent to, but not obstructing, the inner end of the passages whereby the solids of the slurry accumulate quickly as a slug on the former.

4. A machine according to claim 3 so constructed and arranged that advance of the former to cause the slug to project from the die also causes the former to impede the flow of solids through the wall of the die while permitting flow of liquid.

5. A machine according to claim 4 wherein the exhaust means comprises a chamber connected in the operation of the machine with a source of reduced pressure and communicating not only with the dies at the loading station to facilitate rapid accumulation of the slug material but also with at least one die in which the former has been advanced to impede the flow of solids through said passage whereby to facilitate drying of the slug.

6. A machine according to any one of the preceding claims wherein the trimming means comprises a device for emitting a jet of water transversely to a slug to be trimmed.

7. A machine according to any one of the

preceding claims comprising means for collecting for reuse the excess material trimmed from the slug by the trimming means.

8. A machine according to any one of the preceding claims wherein the control means moves the formers in the die to which material has been supplied by the feeding means in the operation of the machine in such a manner as to apply gradually increasing pressure to the material in the die up to a selected maximum pressure.

9. A machine according to claim 8 wherein the control means includes two pressure rolls arranged to act in the operation of the machine on the pair of formers associated with a die whereby to cause the formers to compress the material in the die between the formers to form the pellet.

10. A machine according to claim 9 wherein a first one of the rolls is mounted for rotation about a fixed axis and is arranged to engage a first one of a pair of formers and a second one of the rolls is yieldingly mounted for rotation about an axis the position of which is adjustable relative to the fixed axis.

11. A machine according to any one of the preceding claims wherein the control means is arranged to move the formers in the operation of the machine to eject the pellets from the dies in which they have been formed.

12. A machine according to claim 11 comprising means arranged to direct air through the passages in the dies in the operation of the machine to assist in ejecting the pellets.

13. A machine according to any one of the preceding claims comprising means for collecting for reuse material removed from the dies by the exhaust means.

14. A machine according to any one of the preceding claims wherein adjacent end portions of the formers of each pair have corresponding pellet-shaping projections.

15. A machine according to any one of the preceding claims wherein the dies are readily detachable.

16. A machine according to any one of the preceding claims wherein the control means comprises cams.

17. A pellet-making machine constructed arranged and adapted to operate substantially as hereinbefore described with reference to the accompanying drawings.

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Sheet 1

Fig.1

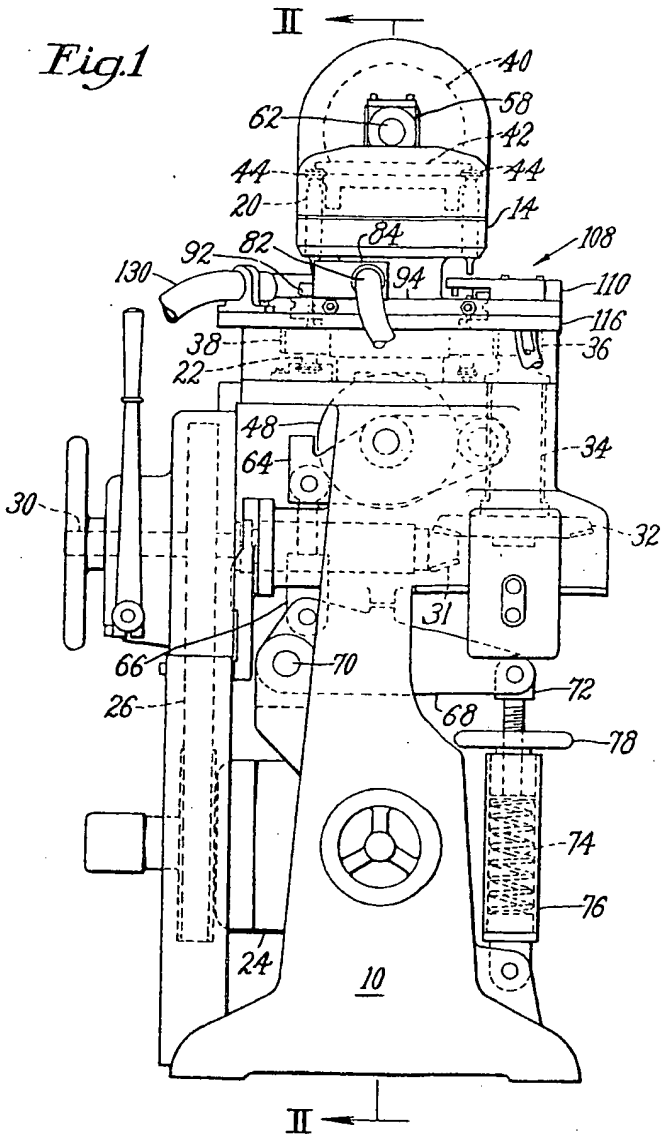

Fig.2

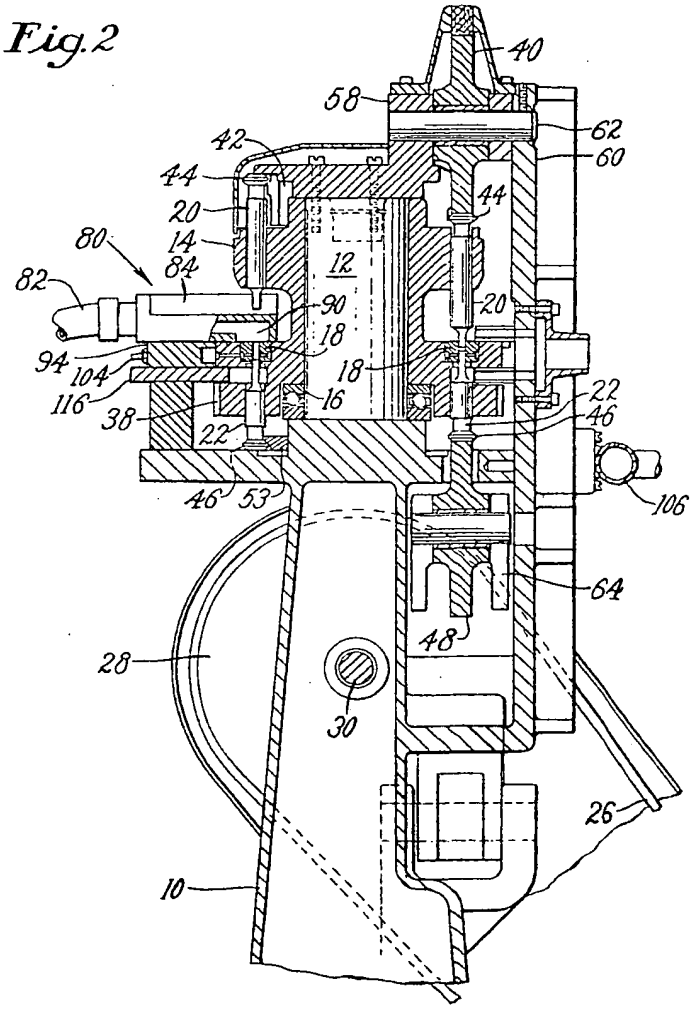
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Fig. 3

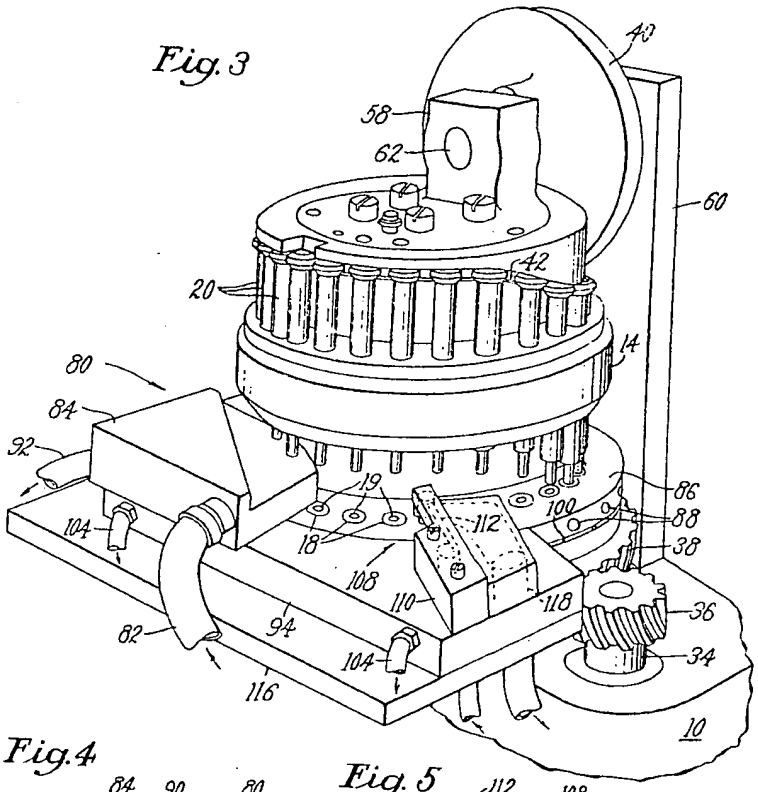


Fig. 4

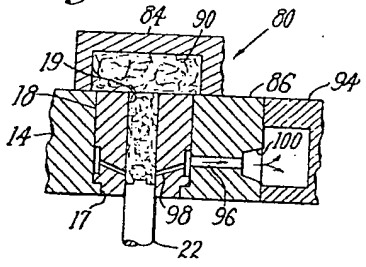


Fig. 5

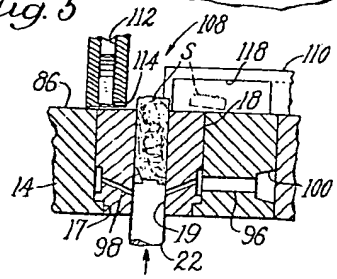


Fig. 6

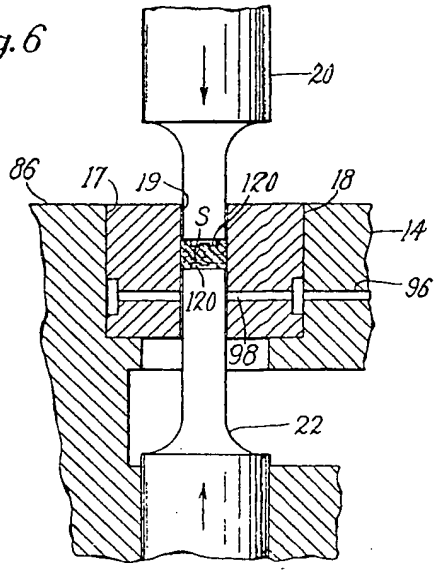
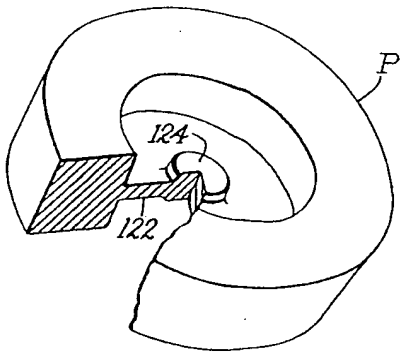


Fig. 7



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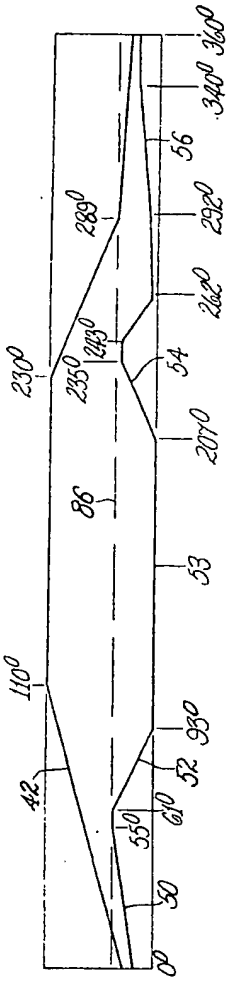

Fig.8

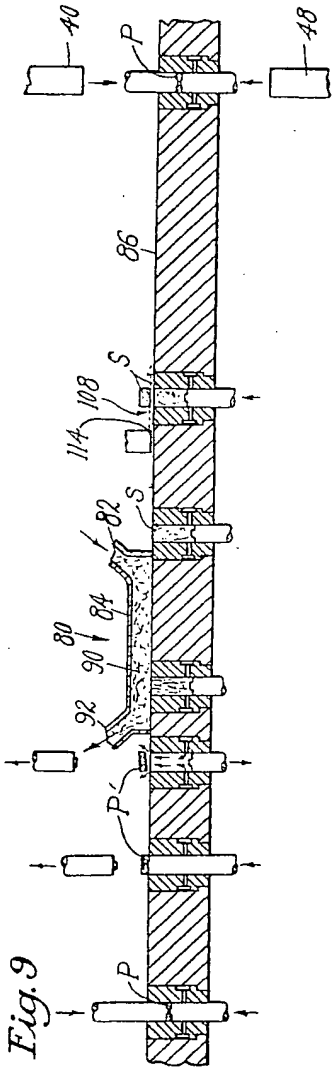

Fig.9

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Fig.10

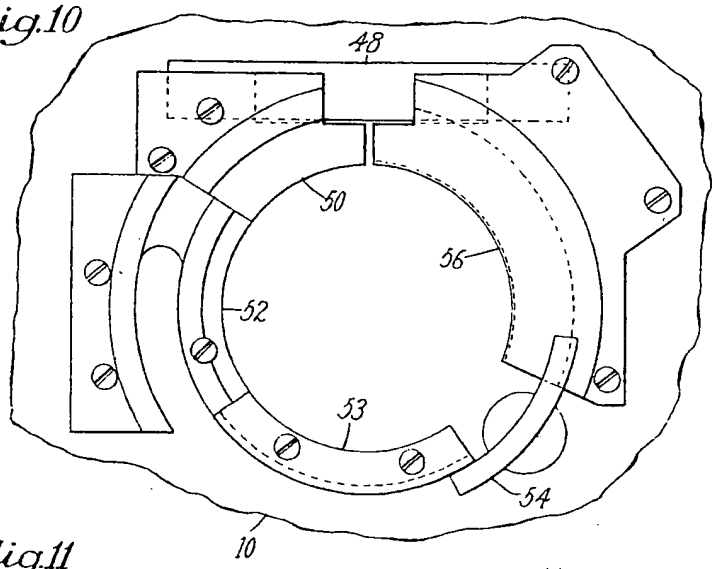

Fig.11